Space Weather Technical Forecast

Issued on Friday 3 January 2025 at 01:26 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: M-class flares likely, with a slight chance of X-class flares. Chance G1 Minor Storms on Day 2 (04 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with one M-class flare, peaking at M1.1 at 02/1740 UTC from AR3939.

There are thirteen sunspot regions on the Earth-facing disc. While AR3936 has rotated of the western limb, it still poses a flare risk for the next 12 hours or so. AR3939, AR3938 and AR3941 have all shown signs of decay over the last 24 hours. AR3944 has grown quickly with the development of further intermediate spots. AR3945 and AR3946s growth appears to have become steady, both retaining a simple beta group at present. There has been several new spots develop, mostly in the eastern hemisphere, with two newly numbered regions, AR3947 and AR3948 in the northeast disc plus two unnumbered regions which have developed in the southeast, close to AR3945 and AR3943 these groups are generally simple at this time but may continue to show growth.

No Earth directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE and DSCOVR at L1, showed ongoing but waning CME influence. Wind speeds have shown a steady decline from 530km/s to 460km/s in the period. Density started above average around 22ppcc falling below average to around 2ppcm. Interplanetary Magnetic Field, Bt, has been largely moderate, with a peak of 13nT at 02/0936 UTC. The north-south component, Bz, was initially weakly positive before becoming weak to moderately negative at 02/0338 UTC. It then returned to weakly positive at 02/1726 UTC. The Phi angle was variable, becoming predominantly positive (away from the Sun) at 02/1732 UTC.

Geomagnetic activity was generally Active with a G1/Minor Storm interval between 02/0900-1200 UT, trending towards mainly Unsettled.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES18 remained background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 03/0000 UTC fluence observation was 4.78e6 integrated pfu.

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Four-Day Space Weather Forecast Summary

Solar Activity: Moderate solar activity is likely to continue with a slight chance of X-flares, this declining somewhat as AR3936 continues to rotate away from the west limb.

Solar Wind / Geomagnetic Activity: There is one potential Earth directed CME, which is expected to pass near Earth early on Day 2 (04 Jan), but with low confidence. Solar winds are currently slightly elevated and continuing to ease following the influence of the two CME arrivals on 31 Dec and 01 Jan. CH05+ may then give elevated wind speeds on Days 2-3.

Geomagnetic activity is expected to be Quiet to Unsettled with isolated Active intervals possible during the first half of Day 1 (03 Dec). Any CME arrival on Day 2 (04 Jan) plus any connection to a high speed stream from CH05+ means that it is likely we will see Active intervals with a chance of G1 Minor storm and a slight chance of G2 Moderate storm intervals. Elevated wind speeds may continue into Day 3 (05 Jan), but geomagnetic activity is forecast to tail off.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to continue at background levels, but with a slight chance of reaching above S1 in response to any larger flares from the western disc. The risk declining a little as AR3936 rotates well away from the west limb. GOES16 high energy electron flux may increase after the recent CME activity, before any further solar wind enhancement suppresses this. The associated fluence is expected to remain below Active, with only a slight chance of rising above.

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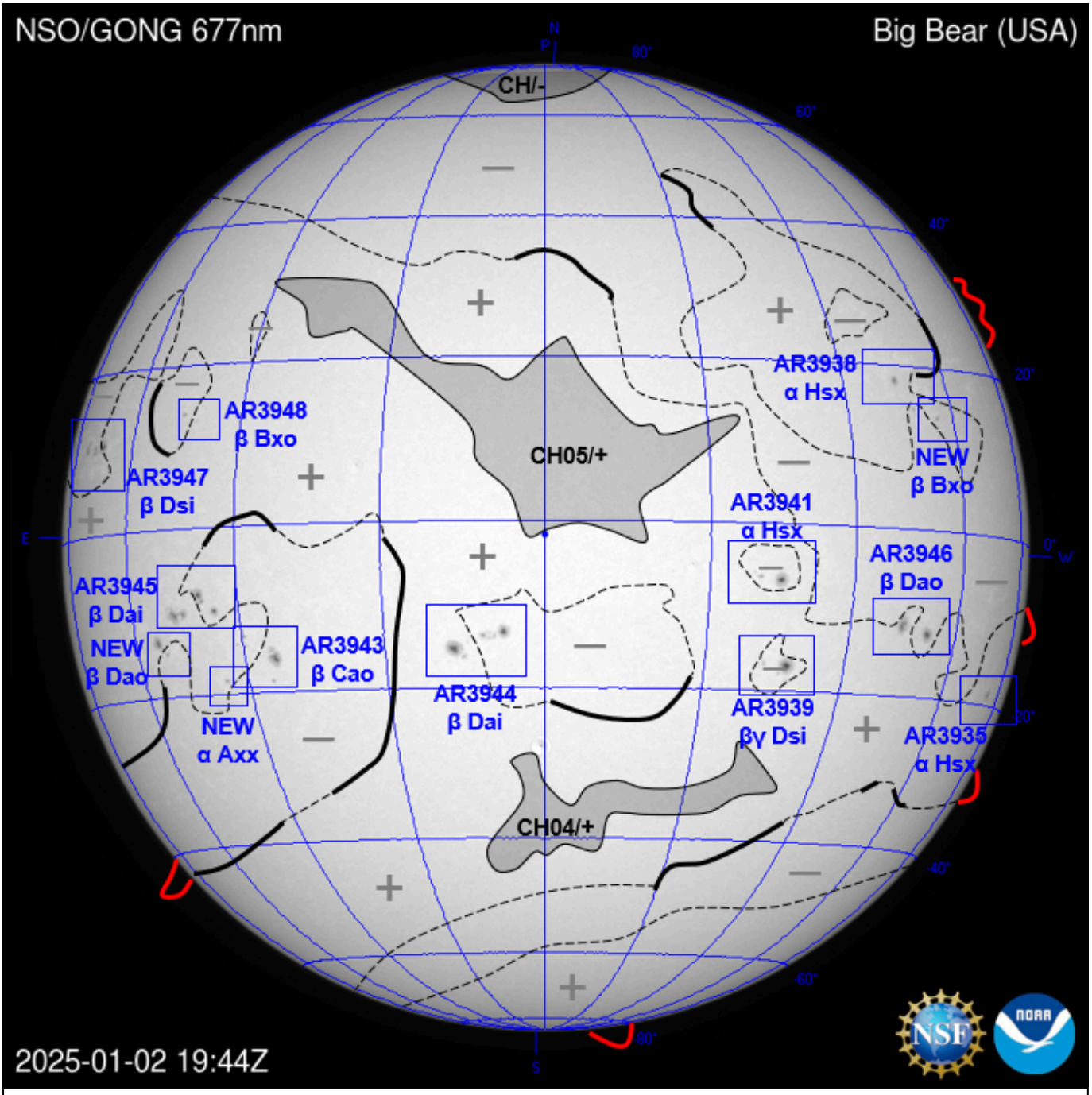
Figure 1: Solar Synoptic Map valid 02/1944 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There is one potential Earth directed CME, from a weak filament eruption early on 01 Jan from the vicinity of AR3939. This is expected to pass near Earth early on Day 2 (04 Jan), perhaps missing ahead of Earth's orbit, but with only glancing effects anticipated if it does arrive.

Solar winds are currently slightly elevated from the aftermath of the the two CME arrivals on 31 Dec and 01 Jan. This is expected to continue to decline through Day 1 (03 Jan). There are currently two notable coronal holes on the Earth-facing disc, CH04+ in the south, and CH05+ in the north. The most likely of these to have an influence on Earth is CH05+, as CH04+ is likely too far south. CH05+ is a persistent feature, and on its previous rotation was a touch smaller and further east. It reached solar wind speeds of around 500-550km/s, reaching Active geomagnetic intervals on the equivalent of Day 3 (05 Jan). Given the current location and the potential for the feature to be stronger than the last rotation, any connection to the high speed stream from CH05+ may arrive slightly earlier than the last rotation, therefor there is a chance we may see some enhancement on Day 2 (04 Jan). The is supported in MOSWOC Enlil output.

Geomagnetic activity is expected to be Quiet to Unsettled with isolated Active intervals possible during the first half of Day 1 (03 Dec). Any CME arrival on Day 2 (04 Jan) could occur alongside the coronal hole enhancement so despite it not being the most favourable time of year for a strong connection to this feature, it is likely we will see Active intervals with a chance of G1 Minor storm and a slight chance of G2 Moderate storm intervals. Elevated wind speeds may continue into Day 3 (05 Jan), but geomagnetic activity is forecast to tail off following the passage of the CIR.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	30	10	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2: MOSWOC Enlil output.

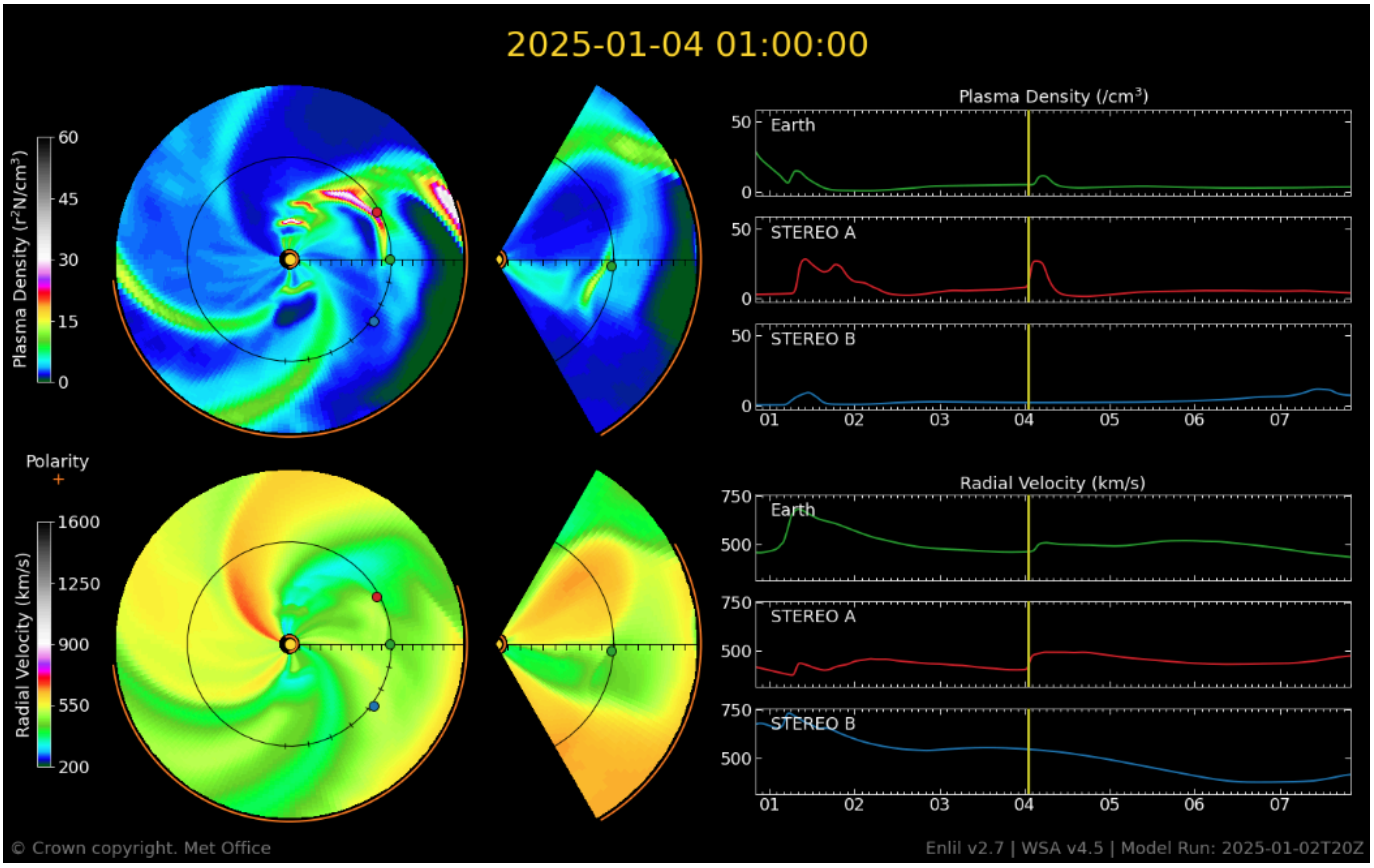
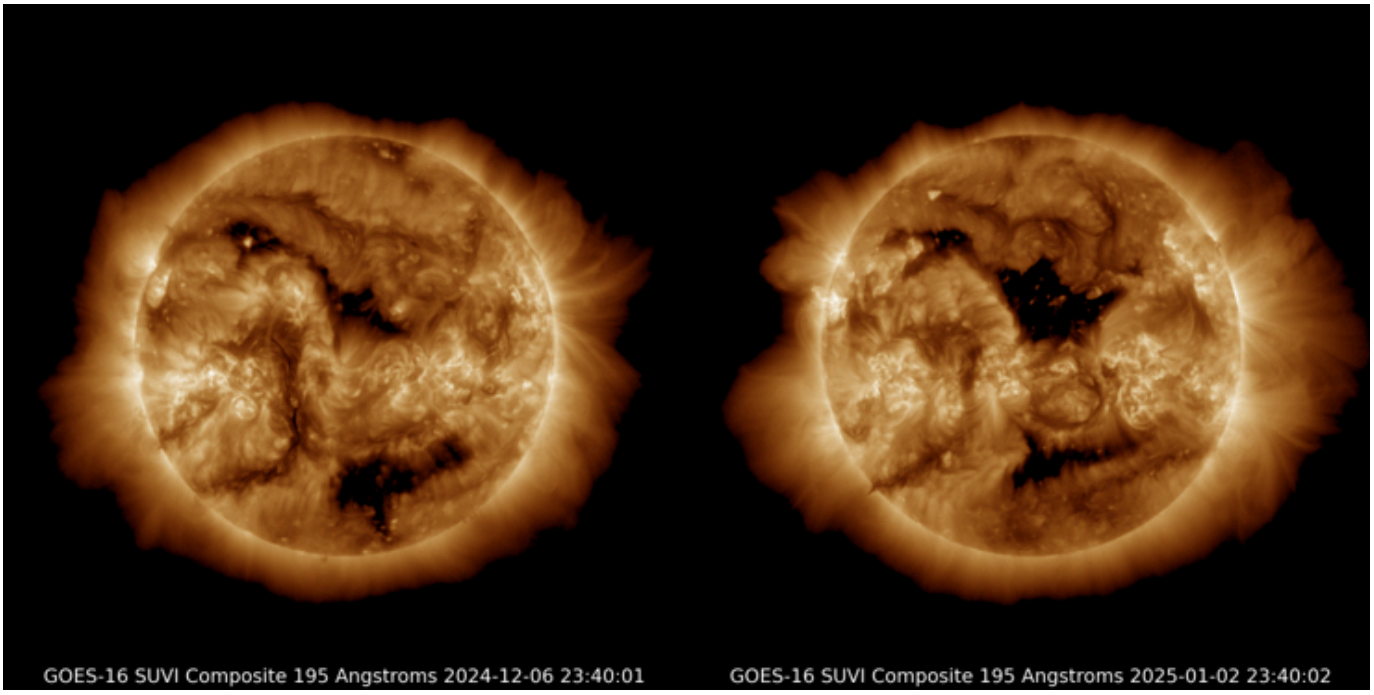


Figure 3: GOES16 SUVI 195 imagery showing the location and size of the coronal holes on the last rotation (left 06 Dec 2024, right 02 Jan 2025)



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Radio Blackouts - X-Ray Flares

Solar activity has persisted at Moderate levels with one M-class flare, peaking at M1.1 at 02/1740 UTC from AR3939.

There are thirteen sunspot regions on the Earth-facing disc. While AR3936 has rotated of the western limb, it still poses a flare risk for the next 12 hours or so. AR3939, AR3938 and AR3941 have all shown signs of decay over the last 24 hours. AR3939, while remaining somewhat complex due to its north-south aligned magnetic structure appears to be loosing some of the smaller leading spots. AR3941 has lost its trailing spots to make it now a unipolar group. AR3944 has grown quickly with the development of further intermediate spots. AR3945 and AR3946s growth appears to have become steady, both retaining a simple beta group at present. There has been several new spots develop, mostly in the eastern hemisphere, with two newly numbered regions, AR3947 and AR3948 in the northeast disc plus two unnumbered regions which have developed in the southeast, close to AR3945 and AR3943 these groups are generally simple at this time but may continue to show growth.

GOES16 SUVI 171 imagery shows some notable magnetic looping on the southeast limb, indicating the possible presence of a new region about to rotate on to the Earth-facing disc in the next 48hours or so. This is supported by far-sided data.

Overall, M-class flaring is likely to continue with a slight chance of X-flares, this declining somewhat as AR3936 continues to rotate away from the west limb.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	60	60	60
Very Active	R3-R5 (X Class)	No	10	10	10	10

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Figure 4: GOES 16 & 18 X-ray trace.

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Solar Radiation Storms (High Energy Protons)

High energy proton flux as observed by GOES-18 is at background levels. There a number of active regions on the Earth-facing disc, including AR3936, which was the source of the most recent X-class flares, and is currently rotating over the northwest limb. Any larger flares, especially from the better Earth-connected western hemisphere, bring a chance of increasing the proton flux, and a slight chance of exceeding the S1 Minor Radiation Storm level. This risk declines slightly through the period as AR3936 rotates further away from the west limb.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	15	15
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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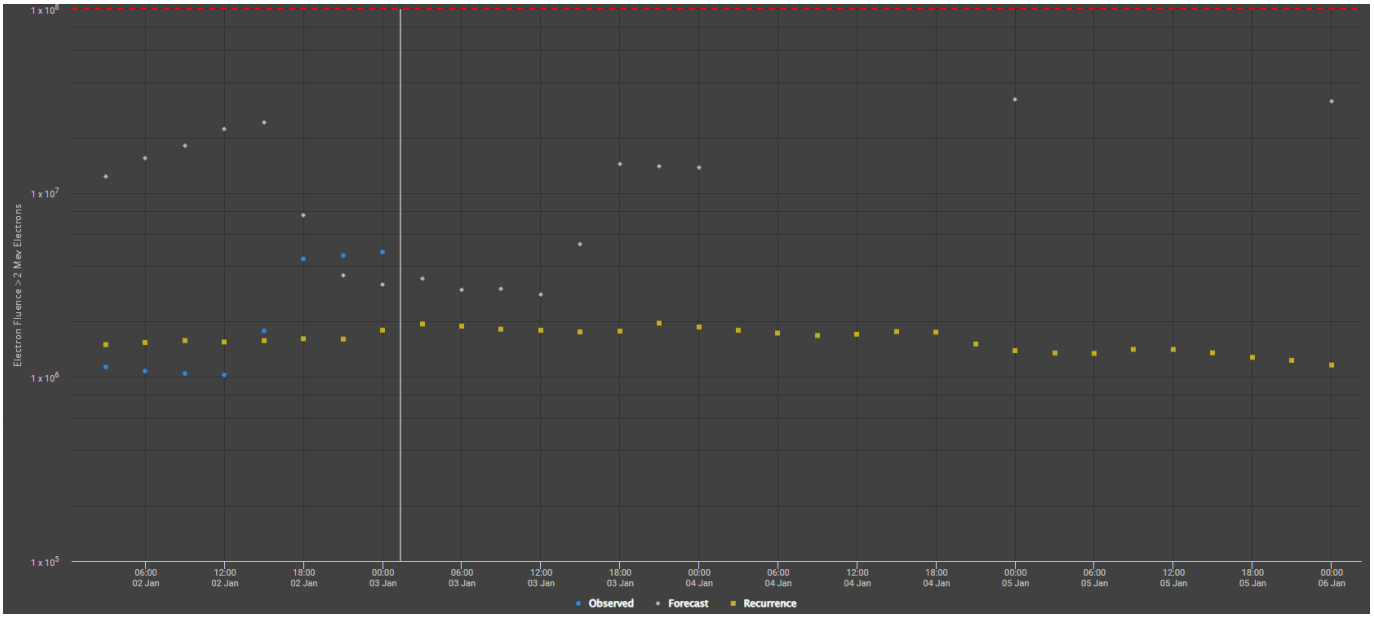
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at background levels after a diurnal peak of moderate. With the solar wind expected to reduce in speed through Day 1 (03 Jan) the Van Allen belt is expected to expand back towards GEO and as a result the electron flux is likely to rise to moderate possibly high at the diurnal max. On Day 2 (04 Jan) a potential glancing CME arrival and possible connection to a high speed stream from CH05+ is forecast to bring elevated solar winds, this may then act to suppress the radiation belt away from GEO causing the electron flux to return to background levels. However, once any initial geomagnetic activity eases, the observed flux could rise again on Day 4 (06 Jan), although this is very low confidence by this time.

Overall the associated 24 hr fluence is most likely to persist below Active, but possibly with a rising trend. This will bring a slight chance for periods of Active fluence, most likely on Days 1 and 2. A rising trend below Active is supported by MOSWOC REFM, which seems like a reasonable trend at this time, although exact values are not to be taken too literally.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	10	15	5	10
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 5: MOSWOC REFM output.



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